

Applicant(s): Eitan Bachmat, Tao Kai Lam and Ruben Michel
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E30-043 (99-202)

In the Claims

Please amend claims 1 and 9 as follows:

1 (amended). A method for determining a seek time required for moving a disk head between first and second addresses on a physical disk drive, said method comprising the steps of:

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- A) dividing the disk into a plurality of segments, each segment having a given size and being defined by first and second boundaries of a plurality of contiguous tracks,
 - B) establishing an array of actual seek times for seek operations between each segment pair based upon the first and second boundaries,
 - C) generating a seek time for disk head movement between the first and second addresses by interpolating the array of actual seek times based upon the first and second addresses.

2. A method as recited in claim 1 wherein said segment division includes dividing the physical disk drive into segments of equal size.

3. A method as recited in claim 2 wherein the segment boundaries and first and second addresses are independent of

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each other and wherein said seek time generation uses the first and second addresses as reference locations in each of the logical blocks.

4. A method as recited in claim 3 wherein each reference is given relative to a predetermined position on the physical disk drive.

5. A method as recited in claim 1 wherein said seek time generation includes the step of generating a linear interpolation based upon the location of the first and second addresses relative to the segment boundaries.

6 (previously amended). A method as recited in claim 5 wherein said linear interpolation is based upon a Ratio Theorem analysis.

7. A method as recited in claim 6 wherein the physical disk drive includes a plurality of data blocks and said interpolation uses a center location for each data block as the reference location to obtain disk seek times for disk seek operations between different data blocks.

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8. A method as recited in claim 6 wherein the physical disk drive includes a data block and said interpolation uses the boundaries of the data block to obtain a disk seek time for seek operations within the data block.

9 (amended). A method for determining the seek time for a physical disk drive configured to store data in a plurality of logical volumes over a time interval, said method comprising the steps of:

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- A) dividing the physical disk into a plurality of fixed sized segments independently of the logical volume configuration on the physical disk drive wherein each segment has a plurality of contiguous tracks,
 - B) determining actual seek times for seek operations between the segments,
 - C) accumulating statistics for each access to each logical volume during the time interval,
 - D) converting the accumulated statistics into an estimated number of seeks between each pair of logical volumes,
 - E) defining a seek time for each logical volume pair based upon said actual segment seek times, and
 - F) generating a total seek time as the sum of the products, for each logical volume pair, of the actual

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seek time for and the estimated number of seeks
between each logical volume in the logical volume
pair over the time interval.

10 (previously amended). A method as recited in claim 9 wherein
said segment seek time determination includes the step of:

- 1) assigning a predetermined seek time for each
seek operation between two segment boundaries,
and
ii) calculating an intrasegment seek time based upon
the predetermined seek times.

11. A method as recited in claim 10 wherein seek time
determination includes the step of placing the
predetermined seek times in a two-dimensional array with
the rows and columns defined by the segment boundaries.

12. A method as recited in claim 9 wherein said accumulation
of statistics includes segregating each access to a logical
volume into one of predetermined classes of accesses and
weighting the numbers of accesses in each predetermined class.


13. A method as recited in claim 12 wherein said segregation
of accesses is into one of random read, write and sequential

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prefetch read classes with weightings of 1.0, 0.5 and 0.25, respectively.

14. A method as recited in claim 13 wherein A_i and A_j represent the weighted access to logical volumes i and j , and A represents the weighted sum of all the accesses to the physical disk drive and wherein the estimated number of disk accesses for the logical volume pair being given by:


$$Nr\ seeks(i,j) = \frac{A_i A_j}{A}$$

15. A method as recited in claim 9 wherein said definition of seek time comprises determining the seek time between a center location of each of the logical volumes in the logical volume pair.

16. A method as recited in claim 15 wherein said definition of seek time includes interpolating the seek times determined for seek operations between the segments based upon the center locations.

17. A method as recited in claim 15 wherein said definition of seek time includes the step of linearly interpolating the seek times determined for seek operations between the segments based upon the center locations.

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18. A method as recited in claim 15 wherein A_i and A_j represent the weighted access to logical volumes i and j , respectively, and A represents the weighted sum of all the accesses to the physical disk drive and wherein the estimated seek time for the logical volume pair is given by:

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$$\text{Seek time } (i,j) = t_{i,j} \frac{A_i A_j}{A}$$

19. A method as recited in claim 9 additionally comprising the step of determining the time for a seek operation within a logical volume.

20. A method as recited in claim 19 wherein said determination of intravolume seek time for a logical volume includes defining the boundaries of the logical volume relative to the segment boundaries and determining the seek time between the logical volume boundaries.


21. A method as recited in claim 20 wherein said definition of intravolume seek time includes interpolating the seek times determined for seek operations between the segments based upon the logical volume boundary locations.

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22. A method as recited in claim 20 wherein said definition of seek time includes the step of linearly interpolating the seek times determined for seek operations between the segments based upon the logical volume boundary locations.

23 (previously amended). A method for determining the seek time over a time interval for a physical disk drive configured to store data in a plurality of logical volumes, said method comprising the steps of:

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- A) dividing the physical disk into a plurality of fixed sized segments characterized by boundaries independently of the logical volume configuration on the physical disk drive,
 - B) determining seek times for seek operations between the segments by assigning empirically derived seek times between two segment boundaries,
 - C) accumulating statistics for each access to each logical volume during the time interval,
 - D) converting the accumulated statistics into an estimated number of seeks between each pair of logical volumes by weighting the numbers of accesses in each of different predetermined classes,
 - E) defining a seek time for each logical volume pair based upon said segment seek times by using the

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center locations of each logical volume to
interpolate the seek times determined for seek
operations between the segments, and

- F) generating a total seek time that is the sum of the
seek times for each logical volume pair obtained as a
function of the estimated number of seeks and the
defined seek time for the logical volume pair.

24 (previously amended). A method as recited in claim 23
wherein each of said center locations is given as an offset
from a segment boundary according to:

$$p = x - [x]$$

and

$$q = [y] - y$$

where x and y represent center line locations of logical
volumes, $[x]$ and $[y]$ represent "floor of x" and "ceiling of y"
functions for the values of x and y based upon the boundaries
of the segments and p and q represent the displacements of the
center line addresses for each logical volume relative to a
segment boundary.

25 (previously amended). A method as recited in claim 24
wherein said definition of seek time for each logical volume
includes the step of generating a seek time according to:

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$$\begin{aligned}
 t_{i,j} = & pq \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil - 1) \\
 & + p(1-q) \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil) \\
 & + (1-p)q \text{ time}(\lfloor x \rfloor, \lceil y \rceil - 1) \\
 & + (1-p)(1-q) \text{ time}(\lfloor x \rfloor, \lceil y \rceil)
 \end{aligned}$$


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 where $t_{i,j}$ represents the seek time for a specific pair of logical volumes and time is the seek interval for the corresponding relationship.

26. A method for determining the seek time over a time interval for a logical volume on a physical disk drive configured to store data in at least one logical volume, said method comprising the steps of:

- A) dividing the physical disk into a plurality of fixed sized segments independently of the logical volume configuration on the physical disk drive,
- B) determining seek times for seek operations between the segments by assigning empirically derived seek times between two segment boundaries,
- C) accumulating statistics for each access to the logical volume during the time interval,

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- D) converting the accumulated statistics into an estimated number of seeks between locations within the logical volume by weighting the numbers of accesses in each of different predetermined classes,
- E) defining a seek time for the logical volume pair based upon said segment seek times by using the boundary locations of the logical volume to interpolate the seek times determined for seek operations between the segments, and
- F) generating a total logical volume seek time that depends upon the number of accesses to the logical volume and the seek times between the boundary locations for the logical volume.

27 (previously amended). A method as recited in claim 26 wherein each of the boundary locations is given as an offset from a segment boundary according to:

$$p = x - \lfloor x \rfloor$$

and

$$q = \lceil y \rceil - y$$

where x and y represent center line locations of logical volumes, $\lfloor x \rfloor$ and $\lceil y \rceil$ represent "floor of x " and "ceiling of y " functions for the values of x and y based upon the boundaries of the segments and p and q represent the displacements of the

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center line addresses for each logical volume relative to a segment boundary.

28 (previously amended). A method as recited in claim 27 wherein said definition of seek time for intravolume seeks includes the step of generating a seek time according to:

$$t_{i,j} = pq \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil - 1)$$

$$+ p(1-q) \text{ time}(\lfloor x \rfloor + 1, \lceil y \rceil)$$

$$+ (1-p)q \text{ time}(\lfloor x \rfloor, \lceil y \rceil - 1)$$

$$+ (1-p)(1-q) \text{ time}(\lfloor x \rfloor, \lceil y \rceil)$$

where $t_{i,j}$ represents the seek time for a specific pair of logical volumes and time is the seek interval for the corresponding relationship.